Current and Future Memory Technologies for your Intel® Architecture Based Platforms

Geof Findley, Sr Manager, Platform Memory Operation, Intel
Harry Yoon, Principal Engineer, Samsung
Agenda

• Intel Memory Usage Roadmap
• Memory industrial status and projection
• DDR3 Health & Industry Enabling Status
• DDR3 Value for DT/WKST/MB/SVR
• Memory education from leading supplier in industry – Samsung

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URL is on top of Session Agenda Pages in Pocket Guide
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Memory Technology Roadmap

Intel offers right memory for the right products

DDR3
- 1333
- LV (1.35V) DDR3 1600 (Server/Client memory)
- 800-1066 (Tablet, Communication, and embedded products)

DDR2
- DDR2 667-800

LPDDR2
- 667-1066 (Smartphones)

2011
2012

All unreleased products, computer systems, dates, and figures specified are preliminary based on current expectations, and are subject to change without notice.
## DDR3 Across Many Major Segments

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Memory</th>
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<tbody>
<tr>
<td><strong>Desktop</strong></td>
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<tr>
<td>HEDT</td>
<td>Intel® Core™ i7 Extreme Processor DDR3 up to 1600 + XMP</td>
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<td>MS</td>
<td>Intel Core i7 and Core i5 Processor DDR3 up to 1333 + XMP</td>
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<td><strong>Mobile</strong></td>
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<td>T &amp; L</td>
<td>Intel Core i5 Processor DDR3 up to 1333</td>
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<td><strong>Server</strong></td>
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<td>EP</td>
<td>Intel Xeon Processor 5600 DDR3 up to 1333 1.5V &amp; 1.35V</td>
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<td>WK/UP</td>
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<td>Intel® Atom™ Processor N450 DDR2/3 up to 800</td>
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<tr>
<td><strong>Tablet</strong></td>
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<tr>
<td></td>
<td>Intel Atom Z760 DDR2 800</td>
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</table>
Agenda

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Supply / Demand

Supply, Demand (m 1Gb EU)

Sufficiency (Supply/Demand)

Q1-11 Q2-11 Q3-11 Q4-11 Q1-12 Q2-12 Q3-12 Q4-12

Supply
Demand
Sufficiency

Source - IHS
Mobile DRAM is gaining bit share
  - 12% in 2010 growing to 25% in 2015

DDR3 shipments surpassed DDR2 in Q1 2010
  - DDR3 now accounts for ~70% of bit shipments

DDR4 will launch in 2012, crossover with DDR3 in mid 2015

Source - IHS
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Intel® Memory Validation

- **DRAM Component Validation**
  - AC/DC testing using Automated Tester at extreme test condition according to specifications
  - RLC testing using Vector Network Analyzer extracting package parasitic data

- **Thermal, Temp Sensor, and Heat Spreader Validation**

- **DIMM System Validation**
  - Functional stress testing at extreme test corners according to specifications
  - System power management testing – power/reset cycle test, S3, C-state test
  - Platform margin testing

- **Thousands of platforms tested for reliable operation by launch**

Comprehensive Validation to Specifications, use Intel® products with reliable memory
Memory Ecosystem for DDR3

-> Leading suppliers shipping in volume...

- DRAM – Samsung*, Hynix*, Micron*, Elpida*, and Nanya*
- Register/Buffer – Inphi*, IDT*, Montage*, and Ti*

DDR3 Ecosystem Very Healthy
Validated DDR3 Memory for Intel® Core™ i7 Processor

Use Intel Validated Memory For Efficient Platform Development
Validated DDR3 Memory for Intel® Core™ i7 Processor

Intel Platform Memory Operations

DDR3 1600 Non-ECC SODIMM Validation Results 1DIMM/ch

Listed below are the results from a small sample of DDR3 1600 Non-ECC SoDIMM modules tested on reference platforms based on Intel® 6 series express chipsets using Intel® Core™ i7 processors (codename Sandy Bridge), in a 1DIMM/channel configuration. We are providing this information as a guide to module performance with Intel® reference platforms. This testing is not intended to replace the normal OEM component qualification process. For results on specific Intel® motherboards or OEM production motherboards, please refer to the OEM’s list of qualified memory suppliers.

<table>
<thead>
<tr>
<th>DIMM Vendor</th>
<th>DIMM Size</th>
<th>DIMM Part#</th>
<th>DRAM Vendor</th>
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<td>4GB</td>
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<td>2Gb8x1048</td>
</tr>
</tbody>
</table>

Use Intel Validated Memory For Efficient Platform Development
Validated DDR3 Memory for Intel® Core™ i7 Processor

http://www.intel.com/technology/memory/

New DDR3 modules added regularly. Please check URL for the most up to date list.

Use Intel Validated Memory For Efficient Platform Development
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Differentiated Desktops
Focused Strategy is Driving Growth

Enthusiast
Performance opportunities

Lifestyle
Form factor is Key

Business
Stable & Reliable

Home Hub
Stable & Reliable

Entry DT
Volume opportunities

Traditional Tower
Undifferentiated, high volume, low ASP
# UltraBook™ Redefining the PC Experience

<table>
<thead>
<tr>
<th>Experience</th>
<th>Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ultra Thin</strong></td>
<td>Aesthetics w/Sleek Industrial Design</td>
</tr>
<tr>
<td><strong>Ultra Mobile</strong></td>
<td>Minimum 12 hr Battery Life</td>
</tr>
<tr>
<td><strong>Ultra Mainstream</strong></td>
<td>Mainstream SPP &lt;$999</td>
</tr>
</tbody>
</table>

**UltraBook™ Redefining PC Memory**
DDR3 Support in Intel® Server Products

- DDR3 continues to be the technology of choice for Intel’s server platforms launching in 2011

2011 and beyond

Intel® Itanium® processor 9000 series
RDIMM

Intel® Xeon® processor 7500/6500 series
RDIMM

Intel Xeon processor 5600 series
RDIMM, UDIMM with ECC, 1.35V RDIMM

Intel Xeon processor 3400 series
RDIMM, UDIMM with ECC

Intel Xeon E7-8800/4800/2800 product families
RDIMM, 1.35V RDIMM

Intel Xeon processor E5 series
RDIMM, UDIMM with ECC, 1.35V, LR-DIMM

Intel Xeon processor E3-1200 product family
UDIMM with ECC

Intel’s Expandable and Mission Critical server products support large memory configurations with the Intel Xeon processor 7510 Scalable Memory Buffer

Intel® server products offer flexibility of memory type to address the range of end user priorities

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Intel® Extreme Memory (Intel® XMP) Profile

- Intel® XMP - expansion of the standard DDR3 memory specification. Enables speeds, latencies outside of JEDEC Specification
  - Contains profiles of pre-tested memory timings in SPD for easy OC
  - DIMM supporting 2010 Intel® Core™ i7, i5 and 2nd Generation Intel Core i7, i5, i3
  - Enables robust, overclocking solution designed to take advantage of the unlocked capability of Intel® CPUs
- Intel® XMP compliant DIMMs available

http://www.intel.com/consumer/game/extreme-memory.htm
Intel® Extreme Memory Profile (Intel® XMP)

How It Works

1. Intel® XMP Enabled BIOS reads module SPD at power-on. JEDEC and XMP Profiles are stored on UDIMM or SODIMM SPD

2. System boots with highest supported JEDEC defined parameters

3. Predefined and tested Intel XMP profiles can be selected by the end user through BIOS setup

4. Reset system to apply

Intel® XMP exceeds JEDEC timings and system voltages: It is overclocking
Summary

- DDR3 provides improved power consumption and performance over previous generations
- Intel continues to promote mobile, desktop, workstation, server adoption of DDR3
- All major suppliers have DDR3 as their volume focused product
- UltraBook™ Redefining PC Memory
- Intel® Extreme Memory Profile defines new levels of memory performance

DDR3 Is Mainstream Now
Samsung DRAM Solution

2011. 09. 14

Memory Product Planning & Application Engineering
Samsung Electronics Co., Ltd.
## Server Segmentation & Memory Requirement

### Usage Model Trend Requirement Memory

<table>
<thead>
<tr>
<th>Usage Model</th>
<th>Trend</th>
<th>Requirement</th>
</tr>
</thead>
</table>
| **High Performance Computing** | MPP (RISC) → Cluster (x86) | TCO: • High Density  
                        |                        | CPU: • High Speed  
                        |                        | Memory: • Low Latency  
                        |                        | RAS: • LRDIMM  
                        |                        |                         |
| **Mission Critical** |                        | TCO: • High Speed  
                        |                        | CPU: • High Capacity  
                        |                        | Memory: • 4Gb DRAM  
                        |                        | RAS: • Standard DIMM  
                        |                        |                         |
| **Conventional (Cost Sensitive Server)** | Standardize & Low cost | TCO: • Green Memory  
                        |                        | CPU: - 1.25V/1.35V  
                        |                        | - Advance Process  
                        |                        | Memory: • Standard DIMM  
                        |                        | RAS: • High supportability  
                        |                        |                         |
| **Cloud Computing & Low End** | Low Computing Power High Connectivity | TCO: • Small F/F DIMM  
                        |                        | CPU: - MiniDIMM  
                        |                        | - ECC SODIMM  
                        |                        | Memory: • 4Gb DRAM  
                        |                        | • Standardization  
                        |                        | • Green Memory  

Source: Intel
**High Density Solution**

**With advanced technology, Samsung offers optimal solution for Server**
- 35nm technology now, 20nm class product available soon

<table>
<thead>
<tr>
<th>Density</th>
<th>Type</th>
<th>Comp.</th>
<th>Org.</th>
<th>Availability</th>
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<tbody>
<tr>
<td>2GB</td>
<td>RDIMM, ECC UDIMM</td>
<td>2Gb</td>
<td>1Rx8</td>
<td>Now</td>
</tr>
<tr>
<td>4GB</td>
<td>RDIMM, ECC UDIMM</td>
<td>2Gb</td>
<td>1Rx4, 2Rx8</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4Gb</td>
<td>1Rx8</td>
<td>Now</td>
</tr>
<tr>
<td>8GB</td>
<td>RDIMM, ECC UDIMM</td>
<td>2Gb</td>
<td>2Rx4, 4Rx8</td>
<td>Now</td>
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<td>4Gb</td>
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<td>16GB</td>
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<tr>
<td>64GB/128GB</td>
<td>Under consideration</td>
<td></td>
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</tr>
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</table>

**Samsung is investigating over 32GB solutions for Ultra High Density Application**
Advanced process technology is driving significant power reduction

Memory Power Consumption Cut by ~30% at Each Process Node

- 50nm class DDR3 1.5V
- 40nm class DDR3 1.5V
- 30nm class DDR3 1.35V
- (Expectation) 20nm class DDR3 1.35V

~65% Savings

- Considered with an 8 hours active and 16 hours idle status in server

Source: Samsung Lab.
More Green & Smooth Transition - DDR4

- Efficient power/ performance

- No significant die size impact with higher speed & less power over DDR3
  - DDR4 POD decreases IO Power & supports higher speed

- Support 1.2V VDD/ VDDQ same as LPDDRx
Emerging Application - Micro-Server

**Micro-server** is a newly emerging server segment aiming the efficiency of performance/power.

**Small form factor module for space minimization**
- Requires power efficient solution (4Gb base 4GB)
- Samsung is supporting 3 types solutions for small form factor requirement

![Micro-server Applications]

**[Small F/ F Solutions of Samsung]**
- **ECC SoDI MM, 2GB/4GB/8GB**: 67.6mm
- **MiniDI MM, 2GB/4GB**: 82mm
- **VLP ECC UDI MM, 2GB/4GB/8GB**: 18.75mm

**Micro-server Applications**
- **Web Server**
- **Application Server**
- **Data base Server**

**Target**
- **Stretch Goal**
Contents

1. Server Trend & Memory Solution
2. PC Trend & Memory Solution
3. Tablet/Smartphone Trend & Memory Solution
4. Long Term Memory Projection
UX (User Experience) is driving new paradigm & Intel Ultrabook™ accelerates this movement

Always On
Always Connected
Mobility

Thin & Light
Accessibility
Longer Battery Life

Conventional Notebook ('11)
Ultra Thin Notebook ('13)

Low Power, Small, Thin & Light, Customized

Cheap & Commodity

CPU
SODIMM
Fan
Thick Battery
HDD

CPU
Solder Down DRAM
Thin Fan
Thin - Wide Battery
SSD
Memory Devices for Ultrathin Notebook

Memory properties required by new transition

- Always-on
- Always-connected
- Instant-on

Mobility

- Low Power
- Fast Responsiveness

Thin/Light

- Mobile DRAM
- Flash Storage

Solder-down

Thickness

- 40-50mm
- 20-30mm
- 8-9 hr
- >12 hr

Battery

- 3 hr
- 5-6 hr
- 13-17mm
- <10mm

Storage

- HDD
- SSD
- Stick SSD

Memory

- Module
- On board
- (1 or 2 chip)
**Investigating various memory configurations**

- 4Gb would be a best-fit in ‘12~’13 timeframe in capacity, power consumption, smaller board area, price, etc.

<table>
<thead>
<tr>
<th>Mobile DRAM</th>
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<th>'12</th>
<th>'13</th>
<th>'14</th>
<th>System config.</th>
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<tbody>
<tr>
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<td>4Gb QDP based 16Gb x64 Comp. 2ea</td>
<td>8Gb QDP based 32Gb x64 Comp. 2ea</td>
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<tr>
<td>4GB</td>
<td>4Gb x32</td>
<td>8Gb x32</td>
<td>8Gb DDP based 16Gb x64 Comp. 2ea</td>
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<tr>
<td>8GB</td>
<td>4Gb x16</td>
<td>4Gb QDP based 16Gb x32 Comp. 4ea</td>
<td>8Gb QDP based 32Gb x64 Comp. 2ea</td>
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<td>4GB</td>
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<tr>
<td>8GB</td>
<td>4Gb Comp. 16ea</td>
<td>4Gb Comp. 8ea</td>
<td>4Gb DDP based 8Gb x32 Comp. 4ea</td>
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128bit System 2ch x64

CPU

CS0 CS1 CS2 CS3
Paradigm Change from PC to Mobile Device

**PC Era**
- **Performance**
  - Personal, Passive
  - Intermittent Connectivity
  - Always Plugged-In

**Mobile Era**
- **Performance**
  - On/Off plug-in
  - Limited mobility

**Watt/Bandwidth**
- Shared, Interactive
  - Always Connected/On
  - Instant on

**Desktop → Notebook**
- Change in performance

**Smartphone/Tablet → Mobile Computing**
- Shift in watt/bandwidth

<table>
<thead>
<tr>
<th>Year</th>
<th>Desktop</th>
<th>Notebook</th>
<th>Smartphone</th>
<th>Tablet</th>
<th>PC total</th>
<th>Mobile total</th>
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<td>360</td>
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<td>150</td>
<td>650</td>
<td>660</td>
</tr>
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</table>

**Q4’10 : Inflection Point**
- PC total < Mobile total

- Desktop < Notebook < Smartphone
- PC total < Smartphone
- Desktop < Tablet

* Source: Global Unit shipment by IDC, Morgan Stanley Research_Feb’11, 2014/2015 forecast based on 2005~2013 CAGR
**LPDDR3 (Low Power DDR3), next DRAM I/F for mobile application**

- Successor of LPDDR2: Low VDD (1.2V), Low IDD6
- Spec under definition in JEDEC

**LPDDR3 JEDEC draft spec will be available in Dec. ‘11**

<table>
<thead>
<tr>
<th></th>
<th>‘11</th>
<th>‘12</th>
</tr>
</thead>
<tbody>
<tr>
<td>JEDEC</td>
<td>Spec under discussion</td>
<td>Draft Spec publish</td>
</tr>
</tbody>
</table>

Note1: 2-Channel (x64) bus
Memory Solution for Tablet/ Smartphone

- **Smartphone**: 512MB/ 1GB/ 2GB LPDDR2, Tablet: 2GB/ 4GB LPDDR3
  - LPDDR3 from ’12 (4Gb, ’12 → 8Gb, ’13)
  - Supporting both POP (2chx32) and discrete (1chx32 or 2chx32)
  - PKG height <1.0mm (up to 4-stacks)

<table>
<thead>
<tr>
<th>Application</th>
<th>’11</th>
<th>’12</th>
<th>’13</th>
<th>’14</th>
<th>’15</th>
<th>System Conf.</th>
<th>CPU</th>
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<td>512MB</td>
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</tr>
<tr>
<td>Smartphone</td>
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<td></td>
<td></td>
<td>2Gb DDP based 4Gb x64 Comp. 1ea</td>
<td></td>
</tr>
<tr>
<td>1GB</td>
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<td>4Gb DDP based 8Gb x64 Comp. 1ea</td>
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<tr>
<td>2GB</td>
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<td></td>
<td></td>
<td>4Gb QDP based 16Gb x64 Comp. 1ea</td>
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<tr>
<td>Smartphone/Tablet</td>
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<td>8Gb DDP based 16Gb x64 Comp. 1ea</td>
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<tr>
<td>4GB</td>
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<td>4Gb QDP based 16Gb x32 Comp. 2ea</td>
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<tr>
<td>Tablet</td>
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<td>8Gb QDP based 32Gb x64 Comp. 1ea</td>
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</tbody>
</table>

64bit System 2ch x32

CS0 CS1 CS2 CS3

Smartphone: 512MB/1GB/2GB LPDDR2, Tablet: 2GB/4GB LPDDR3

LPDDR3 from ’12 (4Gb, ’12 → 8Gb, ’13)
Supporting both POP (2chx32) and discrete (1chx32 or 2chx32)
PKG height <1.0mm (up to 4-stacks)
Contents

1. Server Trend & Memory Solution
2. PC Trend & Memory Solution
3. Tablet/Smartphone Trend & Memory Solution
4. Long Term Memory Projection
**Samsung DRAM Long Term Forecast**

**Samsung builds up the product lineup for all segments**

- Low power memory LPDDR2/3 for mobile device
- Standard DDR3/4 for computing device

<table>
<thead>
<tr>
<th>Interface</th>
<th>Mobile (LP)</th>
<th>Bandwidth</th>
<th>EDP (DDR3)</th>
<th>Bandwidth</th>
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<td>VDD/VDDQ</td>
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<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
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<td>LPDDR2 1.2V/1.2V</td>
<td>LPDDR3 1.2V/1.2V</td>
<td>6.4GB/ s (800Mbps)</td>
<td>DDR3 (1.5V/1.5V, 1.35V/1.35V, 1.25V/1.25V)</td>
<td>10.6GB/ s (1333Mbps)</td>
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<td>8.5GB/ s (1066Mbps)</td>
<td>DDR4 (1.2V/1.2V)</td>
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<td></td>
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<td>25.6GB/ s (3200Mbps)</td>
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</table>
Additional Sources of Information on This Topic:

- Other Sessions – LRDIMM end to end Q&A right after this session in this room
- Demos in the showcase – Samsung, Hynix, and Inphi showing DDR3 and LRDIMMs
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